CLAIMS

1. A lithographic projection apparatus comprising:

a support structure configured to hold a patterning device, the patterning device configured to pattern a beam of radiation according to a desired pattern;

a substrate table configured to hold a substrate;

a projection system configured to project the patterned beam onto a target portion of the substrate; and

a liquid supply system configured to at least partly fill a space between said projection system and said substrate, with a liquid through which said beam is to be projected, said liquid supply system comprising:

a liquid confinement structure extending along at least a part of the boundary of said space between said projection system and said substrate table, and

a gas seal between said structure and the surface of said substrate.

2. Apparatus according to claim 1, wherein said gas seal comprises a gas bearing configured to support said structure over said substrate.

3. Apparatus according to claim 1, wherein said gas seal comprises a gas inlet formed in a face of said structure that opposes said substrate to supply gas and a first gas outlet formed in a face of said structure that opposes said substrate to extract gas.

4. Apparatus according to claim 3, wherein said gas seal comprises a gas supply to provide gas under pressure to said gas inlet and a vacuum device to extract gas from said first gas outlet.

5. Apparatus according to claim 3, further comprising a further inlet connected to a gas source and positioned between said first gas outlet and said gas inlet.

6. Apparatus according to claim 5, wherein said further inlet comprises a continuous annular groove in a surface of said structure facing said substrate.

7. Apparatus according to claim 6, wherein a radially innermost corner of said groove has a radius.

8. Apparatus according to claim 3, wherein said first gas outlet comprises a continuous annular groove in a surface of said structure facing said substrate.

9. Apparatus according to claim 3, wherein at least one of said first gas outlet and said gas inlet comprise a chamber between a gas supply and a vacuum device respectively and a respective opening of said at least one of said first gas outlet and said gas inlet in said surface, wherein said chamber provides a lower flow restriction than said opening.

10. Apparatus according to claim 3, wherein said gas inlet comprises a series of discrete openings in a surface of said structure facing said substrate.

11. Apparatus according to claim 3, wherein said first gas outlet comprises a groove in said face of said structure opposing said substrate, a first passage in said groove connected to a vacuum source and a second passage in said groove connected to a gas supply.

12. Apparatus according to claim 3, wherein a porous member is disposed over said gas inlet to evenly distribute gas flow over the area of said gas inlet.

13. Apparatus according to claim 3, wherein a porous member is disposed over said first gas outlet to evenly distribute gas flow over the area of said first gas outlet.

14. Apparatus according to claim 3, wherein said structure further comprises a second gas outlet formed in said face of said structure that opposes said substrate, said first and second gas outlets being formed on opposite sides of said gas inlet.

15. Apparatus according to claim 14, further comprising a positioning device configured to vary the level of a portion of said face between said second gas outlet and said gas inlet relative to the remainder of said face.

16. Apparatus according to claim 3, further comprising a positioning device configured to vary the level of a portion of said face between said first gas outlet and said gas inlet relative to the remainder of said face.

17. Apparatus according to claim 3, further comprising a positioning device configured to vary the level of a portion of said face between said first gas outlet and an edge of said face nearest said optical axis relative to the remainder of said face.

18. Apparatus according to claim 3, wherein said gas seal comprises a channel formed in said face and located nearer to the optical axis of the projection system than said first gas outlet.

19. Apparatus according to claim 18, wherein said channel is a second gas inlet.

20. Apparatus according to claim 19, wherein said channel is open to the environment above the level of liquid in said space.

21. Apparatus according to claim 3, wherein said gas inlet is located further outward from the optical axis of said projection system than is said first gas outlet.

22. Apparatus according to claim 3, wherein said gas inlet and said first gas outlet each comprise a groove in said face of said structure opposing said substrate and a plurality of conduits leading into said groove at spaced locations.

23. Apparatus according to claim 1, further comprising a sensor configured to measure the distance between said face of said structure and at least one of said substrate and the topography of said substrate.

24. Apparatus according to claim 1, further comprising a controller configured to control the gas pressure in said gas seal to control at least one of the stiffness between said structure and said substrate and the distance between said structure and said substrate.

25. Apparatus according to claim 1, wherein the gap between said structure and the surface of said substrate inwardly of said gas seal is small so that capillary action at least one of draws liquid into the gap and reduces gas from said gas seal entering said space.

26. Apparatus according to claim 1, wherein said structure forms a closed loop around said space between said projection system and said substrate.

27. Apparatus according to claim 1, comprising on a top surface of liquid in said liquid supply system, a wave suppression device configured to suppress development of waves.

28. Apparatus according to claim 27, wherein said wave suppression device comprises a pressure release device.

29. Apparatus according to claim 3, comprising a further gas inlet formed in a face of said structure that opposes said substrate, disposed between said first gas outlet and said gas inlet and angled radially inwardly towards an optical axis of the projection system to provide a jet of gas.

30. Apparatus according to claim 3, comprising a groove formed in a face of said structure that opposes said substrate and disposed between said first gas outlet and said gas inlet.

31. Apparatus according to claim 1, wherein said liquid supply system comprises at least one inlet to supply said liquid onto the substrate and at least one outlet to remove said liquid after said liquid has passed under said projection system.

32. Apparatus according to claim 1, wherein said support structure and said substrate table are movable in a scanning direction to expose said substrate.

33. Apparatus according to claim 1, wherein said liquid supply system is configured to at least partly fill a space between a final lens of said projection system and said substrate, with said liquid.

34. A lithographic projection apparatus comprising:

a support structure configured to hold a patterning device, the patterning device configured to pattern a beam of radiation according to a desired pattern;

a substrate table configured to hold a substrate;

a projection system configured to project the patterned beam onto a target portion of the substrate; and

a liquid supply system configured to at least partly fill a space between said projection system and said substrate with a liquid, wherein said space is in liquid connection with a liquid reservoir through a duct, and the minimum cross sectional area of said duct in a plane perpendicular to the direction of fluid flow is at least $\pi\left(\frac{8\Delta V\eta L}{\pi\Delta P_{\max} t_{\min}}\right)^{1/2}$ where ΔV is the volume of liquid which has to be removed from said space within time t_{min}, L is the length of the duct, η is viscosity of liquid in said space and ΔP_{max} is the maximum allowable pressure on an element of said projection system.

35. The apparatus of claim 34, wherein said space is enclosed such that when liquid is present in said space, said liquid has no free upper surface.

36. A lithographic projection apparatus comprising:

a support structure configured to hold a patterning device, the patterning device configured to pattern a beam of radiation according to a desired pattern;

a substrate table configured to hold a substrate;

a projection system configured to project the patterned beam onto a target portion of the substrate;

a liquid supply system configured to at least partly fill a space between said projection system and said substrate with a liquid, said liquid supply system comprising on a top surface of liquid in said liquid supply system, a wave suppression device configured to suppress development of waves.

37. Apparatus according to claim 36, wherein said wave suppression device comprises a flexible membrane.

38. Apparatus according to claim 36, wherein said wave suppression device comprises a mesh such that the maximum area of said top surface of said liquid is equal to the mesh opening.

39. Apparatus according to claim 36, wherein said wave suppression device comprises a high viscosity liquid which is immiscible with said liquid.

40. Apparatus according to claim 36, wherein said wave suppression device comprises a pressure release device.

41. Apparatus according to claim 40, wherein said pressure release device comprises a safety valve configured to allow the passage therethrough of liquid above a certain pressure.

42. A lithographic projection apparatus comprising:

a support structure configured to hold a patterning device and movable in a scanning direction, the patterning device configured to pattern a beam of radiation according to a desired pattern;

a substrate table configured to hold a substrate and movable in a scanning direction;

a projection system configured to project the patterned beam onto a target portion of the substrate using a scanning exposure; and

a liquid supply system configured provide a liquid, through which said beam is to be projected, to a space between said projection system and said substrate, said liquid supply system comprising:

a liquid confinement structure extending along at least a part of the boundary of said space between said projection system and said substrate table,

a gas inlet formed in a face of said structure that opposes said substrate to supply gas,

a gas outlet formed in a face of said structure that opposes said substrate to extract gas,

an inlet to supply said liquid to said substrate, and

an outlet to remove said liquid after said liquid has passed under said projection system.

43. Apparatus according to claim 42, wherein said liquid supply system provides liquid to only a localized area of said substrate.

44. Apparatus according to claim 43, wherein said area has a periphery conforming to a shape of an image field of said projection system.

45. Apparatus according to claim 42, wherein said inlet supplies said liquid at a first side of said projection system and said outlet removes said liquid at a second side of said projection system as said substrate is moved under said projection system in a direction from the first side to the second side.